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Type of Organization: College or University

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Project Title: Enhanced Bioremediation of Polychlorinated Biphenyl (PCBs).

Project Category: Contaminated Sediments

Rank by Organization (if applicable): 0

Total Funding Requested ($): 188,260 **Project Duration:** 2 Years

Abstract:

This project addresses the concern for elimination of polychlorinated biphenyls (PCB) in paper-mill wastes and sediments located in the Fox River, Green Bay, and Kalamazoo Rivers. These wastes serve as potential ongoing PCB-contamination sources to the Fox River and Green Bay in Wisconsin, to Portage Creek, the Kalamazoo River in Michigan, and ultimately, Lake Michigan from waste impoundments and sludge lagoons located in the Areas of Concern (AOC). Polychlorinated-biphenyl contamination of these wastes and sediments are a result of the use of Aroclor 1242 in the production of carbonless copy paper (3.5 percent by weight) from 1957 to 1971. The objective of this project will be to evaluate overall feasibility of a number species of white-rot fungi and bacteria in remediation of Aroclor 1242 from contaminated wastes and sediments. Preliminary work with several species of white-rot fungi has demonstrated enhanced degradation of Aroclor 1242 PCB congeners in the presence of natural surfactants. This study will begin with a complete physical/chemical characterization of the contaminated sediments and paper-mill sludge. This characterization will provide information on the nutrient status, pH and other aspects of the materials; identification and quantification of PCB congeners and other pollutants; and a determination of whether PCBs exist as free product or whether a fraction remains encapsulated. This information will be used in the design of treatability studies that will evaluate the ability of selected fungi and bacteria to degrade Aroclor 1242 PCB congeners. The information generated from the treatability, surfactant and inoculum work will then be used in the on-site, pilot-scale demonstration of enhanced biological treatment of the contaminated sediments and sludge. This on-site pilot will be conducted at a Georgia Pacific facility in Michigan using sediments that have been dredged from the Kalamazoo River.

Geographic Areas Affected by the Project

States:

- [ ] Illinois
- [ ] Indiana
- [x] Michigan
- [ ] Minnesota
- [x] New York
- [ ] Pennsylvania
- [x] Wisconsin
- [x] Ohio

Lakes:

- [ ] Superior
- [ ] Huron
- [x] Michigan
- [x] Erie
- [ ] Ontario
- [ ] All Lakes

Geographic Initiatives:

- [ ] Greater Chicago
- [ ] NE Ohio
- [ ] NW Indiana
- [ ] SE Michigan
- [ ] Lake St. Clair

Primary Affected Area of Concern: Kalamazoo River, MI

Other Affected Areas of Concern: Menominee River (Wisconsin)
Milwaukee Estuary (Wisconsin)
Manistique River (Michigan)
Menominee River (Wisconsin)
Muskegon Lake (Michigan)
Niagara River (New York)
Oswego River/Harbor (NewYork)
Rochester Embayment (New York)

For Habitat Projects Only:

Primary Affected Biodiversity Investment Area:

Other Affected Biodiversity Investment Areas:

Problem Statement:

This project addresses the concern for elimination of polychlorinated biphenyls (PCB) in paper-mill wastes and sediments located in the Fox River (the largest tributary PCB contributor to Lake Michigan), Green Bay, and the Kalamazoo River. These wastes and contaminated sediments serve as potential ongoing PCB-contamination sources to the Fox River and Green Bay in Wisconsin and to Portage Creek and the Kalamazoo River in Michigan, and ultimately, Lake Michigan. Contamination of the Kalamazoo and Fox Rivers has resulted in restrictions on fish and wildlife consumption, dredging activities, and beach use, as well as degradation of fish and wildlife populations and habitat. Reclamation of these natural resources requires elimination of PCB-source contamination. PCB contamination of these wastes and sediments is a result of the use of Aroclor 1242 in the production carbonless copy paper (3.5 percent by weight) from 1957 to 1971. Aroclor 1242 was used as an ink carrier and solvent for color reactants, which were encapsulated into microcapsules. The microcapsules were 10 to 20 microns in diameter, with walls initially consisting of a hardened gelatin gum Arabic. Later, other materials were introduced to indurate the microcapsule walls. The fate of these capsules in the various wastes and sediments has yet to be investigated. Therefore, PCB congeners present in the paper mill waste and sediments may remain encapsulated or, if capsule walls have not survived, exist as free oils. Based on preliminary work that demonstrates the potential efficacy of the technolog, we propose the use of enhanced bioaugmentation, a technology which is based on the demonstrated PCB-degrading abilities of non-native bacteria and/or fungi, to eliminate PCBs from the millions of tons of paper mill waste and sediments that exist in the Kalamazoo and Fox Rivers downstream of pulp and paper mills. The use of surface-active agents will also be addressed for enhanced efficiency of microbial pollutant-degrading systems in degradation of hydrophobic pollutants (e.g. PAHs, PCBs). The large volumes of PCB-contaminated sediments and pulp mill waste dictate the use of a low-cost remediation technology. Solid inocula can account for as much as one-third to one-half the cost of fungal-based remediation. To make treatment of these materials economically feasible, the development of lower cost liquid fungal/bacteria inocula will be developed to replace solid substrate inocula.

Preliminary Results: Preliminary work in our laboratory with several species of white-rot fungi has demonstrated enhanced degradation of Aroclor 1242 PCB congeners in paper-mill sludge in the presence of natural surfactants after 28 days of treatment, of selected PCB congeners (i.e. those found in highest concentration) by the white-rot fungus with Bjerkandera Bos in surfactant-amended soil.

Proposed Work Outcome:

The study will begin with a complete physical and chemical characterization of the contaminated sediments and paper-mill sludge. This characterization will provide information on the nutrient status, pH, and other aspects of the materials; identification and quantification of PCB congeners and other pollutants; and a determination of whether PCBs exist as free product or whether a fraction remains encapsulated. This information will be used in the design of treatability studies that will evaluate the ability of selected fungi and/or bacteria to degrade Aroclor 1242 PCB congeners and any other pollutants that might be present. In preliminary work, we have found that natural surfactants have greatly enhanced the fungal degradation of selected Aroclor 1242 PCB congeners. With the expected increased cost of surfactant additions, a number of industrial byproducts will be evaluated that have surface-active properties similar to those provided by the natural surfactant products. Additionally, the possibility of using liquid fungal inoculum will be evaluated as a lower-cost alternative to solid substrate fungal inocula for delivery of fungi and/or bacteria to the contaminated materials. The information generated from the treatability, surfactant and inoculum work will then be used in the on-site, pilot-scale demonstration of enhanced biological treatment of the contaminated sediments and sludge. The on-site pilot will be conducted at a Georgia Pacific facility in Michigan using sediments that have been dredged from the Kalamazoo River. We will include a letter of agreement from Georgia Pacific in the full proposal, which indicates its willingness to provide the site and some in-kind contributions.

Specific Objectives:

1. Physical/chemical characterization of contaminated river sediments and paper-mill sludge.
2. Screen and select the most effective fungal and/or bacterial PCP-degrading isolates.
3. Evaluate the ability of fatty-acid surfactants to enhance fungal and/or bacterial PCB degradation.
4. Compare the performance (i.e. ability to support fungal and/or bacterial growth and pollutant degradation) of low-cost liquid inoculum formulations to conventional solid substrate inocula.
5. Conduct an on-site, pilot-scale technology demonstration to (1) evaluate the ability of the best treatment to meet or exceed PCB-cleanup goals on PCB-contaminated Kalamazoo River sediment; and, (2) conduct an economic analysis of the technology.

The outcome of the proposed work will be a biologically based, economically attractive technology for the degradation of PCBs in sediments and paper-mill sludge. In addition, it is hoped that; 1) the work with the surfactants will extend the use of bioremediation to treatment of extremely hydrophobic pollutants like PCBs and high molecular weight PAHs, and 2) that a low-cost, liquid inocula can be developed to replace solid substrate inocula for fungal-based remediation to greatly decrease the cost of the technology.

Project Milestones:	**Dates:**
Project Start	06/2000
Sediment and Sludge Characterization	07/2000
Id. of Most Eff. PCB-Degrading Microbes	12/2000
Assesment of Surfactants	02/2001
Assesment of Liquid Inocula Formulations	06/2001
On-Site Demonstration	05/2002
Final Report	06/2002
Project End	06/2002

☒ Project Addresses Environmental Justice

If So, Description of How:

Many PCB sites have been located in older industrial sites and close to rivers and lakes. It has been very difficult to clean up these sites due to the stability of these compounds. Conventional biological techniques are very slow with these types of products, due to the contaminants limited solubility in water. Incineration technologies have been used at some sites to clean up PCB contaminated soil and sediment but the cost and problems of permitting portable incinerators have limited the use of this technology. Because these sites are so difficult to remediate there has been continual exposure of people, fish and other organism to low levels of PCB's both in the water and air (attached to dust particles). With this in mind there is a serious need for development of a less expensive and effective method of (biological) remediation of these types of wastes, so that people who live close to these sites and fish and other organisms will have less exposure to the chemicals.

☒ Project Addresses Education/Outreach

If So, Description of How:

This program will involve both undergraduate and graduate students in the research phase of the program. The graduate students will be funded from Michigan State funds. If possible we will also hold a public meeting at the site to inform the general public on the purpose of the study. The results of this study will be presented at a professional meeting and published in a peer reviewed publication. We will also take advantage of other opportunities to speak and publish on the results from this study.

Project Budget:

	Federal Share Requested ($)	Applicant's Share ($)
Personnel:	39,175	0
Fringe:	12,536	0
Travel:	8,000	0
Equipment:	13,000	0
Supplies:	5,000	0
Contracts:	75,650	0
Construction:	0	0
Other:	0	0
Total Direct Costs:	153,361	0
Indirect Costs:	34,899	0
Total:	188,260	0
Projected Income:	0	0

Funding by Other Organizations (Names, Amounts, Description of Commitments):

Our current source of funding include the following:

State funds
Funds from industrial companies including ABTco and the Weyerhaeuser corporation
Current proposals have been submitted to the National Science Foundation and the Department of Energy

Description of Collaboration/Community Based Support:

This joint effort between the environmental group at Michigan Technological University (MTU) and Earthfax creates a well-rounded research team with a wide range of expertise in many facets biological treatment of environmental contaminants. Earthfax has conducted a variety of biological studies including pilot plant and site remediation using fungal bioremediation of recalcitrant compounds. The environmental group at MTU has worked at over 25 superfund sites using a variety of bioremediation technologies, and has a strong program in soil and analytical chemistry and biological expertise.